PROPOSAL FOR TOPIC APPROVAL TO BE SUBMITTED TO THE UNIVERSITY OF MUMBAI FOR THE PH.D DEGREE IN THE SUBJECT OF PHYSICS.

Title of the topic	:	Study of Physical Properties of Nematic Liquid Crystalline Material doped with Metal-Oxide Nanoparticles.
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Research Proposal

1. Title-: Study of Physical Properties of Nematic Liquid Crystalline Material doped with Metal-Oxide Nanoparticles.

2. Aim of study -:

Liquid crystals (LCs) are well known for their anisotropic properties and are classified according to the ordering and geometry of their molecules. [1,2] Nanoparticles exhibit specific physical and chemical properties due to their large interaction surface area and nanoscale size.[3]. Metal oxide nanoparticles (MO-NPs) have attracted a great deal of interest on the grounds of them diverse properties in the recent times. The present research work is an attempt to investigate various physical properties of Nematic liquid crystalline material doped with Metal-oxide nanoparticles by using numerous experimental techniques. The liquid crystal composites will be prepared by adding an appropriate concentration of Metal-oxide nanoparticles in different liquid crystal compound.

3. Objectives of Study-:

Physical properties of liquid crystals such as orientational order parameter, birefringence, dielectric permittivity, etc. are necessary to describe the applicability of liquid crystals in various fields. These properties can be modified by doping them with Metal-oxide nanoparticles. These Metal-oxide nanoparticles doped Nematic liquid crystalline materials are found to change these properties significantly.[4]. The present research work deals with the studies and effects on these properties of the Nematic liquid crystal compounds.

- The present research work deals with the changes in properties and also highlights the effect and importance of doping Nematic liquid crystalline material with Metal-oxide nanoparticles.
- To identify mesophases/textures of Nematic liquid crystalline material doped Metal-oxide nanoparticles.
- To determine Acoustical properties of Nematic liquid crystalline material and doped Metal-oxide nanoparticles.
- Study of Refractive Indices with wavelength and temperature of Nematic liquid crystal compound and liquid crystals doped with different Metal-oxide nanoparticles.

All these above doping will be carried out using different concentrations of doping material, that is Metal-oxide nanoparticles such as Cobalt oxide (CoO), Nickel Oxide (NiO), Tin oxide (SnO_2), Titanium dioxide (TiO_2) etc.

4. Study background (Literature review) & Significance Study-:

The first observation of this wonderful class of matter was knocked on the door in the 1850s by biologists and very soon physicists and chemists joined the fray. German physicist Otto Lehman and Austrian botanist Friedrich Reinitzer verified the discovery in 1888 by observing the melting behavior of an organic substance Cholesteryl benzoate, the outgrowth of cholesterol. He found that cholesteryl benzoate does not melt in the same manner as other compounds, but has two melting points. At 145.5 °C it melts into a cloudy liquid, and at 178.5 °C it melts again and the cloudy liquid becomes clear. The phenomenon is reversible. [5-8]. In 1900, Lehman with the definition ***"It is a new state of matter possessing the optical properties like solids and fluid properties like liquids"*** began the term ***'liquid crystal'*** for such phases of matter.[5] **Daniel Vorländer** was a German chemist who synthesized most of the liquid crystals. George William Gray, in 1973, in conjunction with the Royal Radar Establishment, he showed that 4-Cyano-4'-pentylbiphenyl possessed a stable nematic phase at room temperature. Sivaramakrishna Chandrasekhar in India in 1977 has synthesis disc-shaped LC.

The liquid crystal is classified as – 1. Thermotropic liquid crystal- Thermotropic liquid crystals are those that exhibit liquid crystalline phase(s) in a certain temperature range. 2. Lyotropic liquid crystal- LC phases formed by dissolving the compound in an appropriate solvent (under given concentration and temperature conditions) are known as lyotropic. The anisotropy of liquid crystals which arises due to the molecular shape and the order existing in the constituent molecules manifests itself in the elastic, electric, magnetic and optical properties. Many applications of liquid crystals rely on their anisotropic physical properties and their response to external perturbations like temperature, mechanical stress, electric, magnetic fields, etc. [9].
Liquid Crystals (LCs) are soft condensed matters which can flow like conventional liquids and also have properties of crystalline solids. They play a vital role in modern technology due to their photonics and display applications like optical imaging, organic light-emitting diodes, erasable optical disks, light modulators, full-color electronic slides for computer-aided design, optical antenna, etc. [10-13].

LCs with the addition of MO-NPs have been the subject of intense research, as it had brought myriads of changes in their characteristics as well as in their arrangement. MO-NPs exhibit different types of conductivity owing to their oxidation states and defects.[14]

5. National Status-:

Liquid crystal materials are unique in their properties and uses. As research into this field continues and as new applications are developed, liquid crystals will play an important role in modern technology. The Center for Liquid Crystal is in Bangalore. Different work has been done in the liquid crystal field. At the National level different research is done that is magnesium oxide nanoparticles doped into nematic liquid crystalline mixtures not only magnesium oxide but also so many different nanoparticles for example copper oxide, carbon nanotube, graphene oxide, etc. doped with liquid crystalline composites. Liquid crystalline elastomers are stimuli-responsive polymeric materials whose mechanical properties can be programmed by patterning their local orientation, making them promising candidates to serve as low-density actuators and functional elements in various applications. Synthesis and processing of liquid crystalline elastomers, with a focus on alignment methods and potential applications.

6. International Status-:

An Advanced and Liquid Crystal Institute is at Kent State University. At the International position too, numerous explorations have been done in the liquid crystal field that is electro-optical and dielectric properties of 6CHBT Nematic liquid crystals doped with Magnesium oxide Nanoparticles. Synthesis and properties of isothiocyanate liquid crystals containing cyclohexene unit. To study the physical properties of liquid crystals doped with CSPbBr3 quantum dots. Impact of doped Graphene oxide on thermodynamical, optical, electro-optical, and dielectric properties of Nematic liquid crystal.

7. Study Hypothesis-:

Nanoparticles of different materials are unique because of their stimulating properties which are different from their bulk counterparts. It is expected that when MO-nanoparticles are dispersed in any liquid crystal material to make liquid crystal nanocomposite, they may share their intrinsic properties with the liquid crystals host. This improves the various kinds of properties of the existing liquid crystals used for various optical devices and display applications. The hypothesis of our proposed work is to carry out investigations in the following manner

- A study of the physical properties of Nematic liquid crystalline material doped with Metal-Oxide nanoparticles.
- A comparative study of different Metal oxide nanoparticles doped in Nematic liquid crystalline material with different concentrations.

8. Study Rationale-:

Liquid crystals are anisotropic in nature and some of their properties depend on the direction along which that is oriented. Technologically, they have gained enormous success in display and photonic applications. The order of stability of the different phases on a scale of increasing temperature is simply by utilizing the fact that a rise in temperature leads to progressive destruction of molecular order. Thus, the less symmetric the mesophase is the closer in temperature it lies to the crystalline phase. Liquid crystal is highly transparent in the visible and near-infrared wavelength regions. This study includes the use of different MO-nanoparticles for doping liquid crystalline material. Defects and textures in liquid crystalline phases are important because it allows for the characterization and classification of mesophase type where the combinations of textures can be used. It gives information about the mesophase structure. Optical anisotropy is an essential physical property of liquid crystals for application in liquid crystal display devices. Because of optically anisotropic materials, the speed of propagation of light waves is dependent upon the direction and polarization of the light waves traversing through the material. Owing to this, the material possesses different refractive indices in different directions. The study of guest material (MO-Nanoparticles) doped liquid crystalline material has shown its importance in modifying and tuning the properties of host LC. The role of MO-nanoparticles is very important to obtain different physical properties of liquid crystals. MO-Nanoparticles doped liquid crystal research has attracted great interest in recent years.

9. Research Methodology-:

Liquid crystals are known for their immense applications in various fields. These are highly promising and extensively useful materials in many displays and non-display devices. These devices utilize various basic properties of a particular LC material. So, it becomes important to characterize these LC materials according to their suitability for any particular application. Different experimental techniques and methodologies will be used to measure the physical properties of Nematic liquid crystalline material doped with MO-nanoparticles more accurately and to avoid the experimental error, it is necessary to adopt a standard measurement procedure.

- To measure the Refractive Index of Nematic Liquid Crystal by Abbe's Refractometer.
- To identify mesophases and their thermal behavior of Nematic liquid crystalline material and MO-nanoparticles doped with Nematic liquid crystalline material by using Differential Scanning Calorimetry.
- To measure Acoustical properties of Nematic Liquid Crystal and MO-nanoparticles doped on Nematic liquid crystal using an Ultrasonic Interferometer.
- To study of Refractive Indices with wavelength and temperature of Nematic liquid crystal compound and doped with different MO-nanoparticles by using multiple wavelength refractometer.
- To identify mesophases/textures of Nematic liquid crystalline material doped Metal-oxide nanoparticles. This mesomorphic study will be carried out using Hot Stage Polarizing Optical Microscope (POM) and Fabry Perot Spectroscopic Studies (FPSS).

10. Statistical plan-:

- Refractive Indices with wavelength and temperature will be analyzed by Abbe's refractometer.
- The surface and temperature-induced LCs and alterations in mesophases will be examined by a Polarizing Optical Microscopy.
- Phase transition temperature by Fabry Perot Spectroscopic Studies.
- Mesophases and their thermal behavior of liquid crystal will be done by using Differential Scanning Calorimetry.
- Acoustical properties will be measured using Ultrasonic Interferometer.

11. Limitations of study-:

The limitation of these studies is the synthesis of liquid crystals.

12. Expected outcomes of study-:

- The changes in physical properties and effect of doping Nematic liquid crystalline material with Metal-oxide nanoparticles will be studied.
- Identification of mesophases and phase transitions temperature using Hot stage Polarizing Optical Microscope.
- Confirmation of phase transition temperature by using Fabry Perot Spectroscopic Studies.
- Identification of mesophases and their thermal behavior by using Differential Scanning Calorimetry.
- The various acoustical properties like ultrasonic velocity, density, Adiabatic Compressibility, etc will be determined by Ultrasonic Interferometer at different temperatures at various frequencies.

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